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INTERACTIVE METHODS IN ENGINEERING DESIGN EDUCATION: OUR EXPERIENCE

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ABSTRACT
Under the conditions of rapid technological and cultural changes new challenges emerge for design educators. It is necessary to update and modernize the outdated educational process, including design education. This paper demonstrates our attempt to introduce new non-conventional methods in engineering design education in two fundamental disciplines such as *form-formation* and *theory of composition*. Traditionally it is accepted that knowledge can be directly transferred from the teacher to the student. Contrary to this, in interactive education students become constructors of their own knowledge while learning becomes an active quest for meanings and values – a co-participation in the educational process. Dialogue is established as the most common and underlying form of knowledge, and interchange of ideas. In search of heuristic solutions the most problematic and conflicting issues are discussed. In this paper, examples for the thematic broadening of the disciplines through their interdisciplinary correlation will be presented. Different possibilities for updating the education through introduction of the novel acquisition of scientific knowledge will be shown. The aim is to provide students with a range of options to extend further their knowledge, to motivate them to interpret the relevant information and apply it in their future work. Various established forms of student participation in the educational dialogue will be analyzed. The importance of development of heuristic thinking through analyzing problems, generalizing principles, proposing and arguing solutions is underlined. Special attention is paid to the application of the idea for competitiveness, which supports and contributes to activation and intensification of the educational process.

Keywords: Methodology of design education, updating the education, interactive method, form-formation, theory of composition

1 INTRODUCTION

The most common characteristic of the time we live in is change. Defined by dynamic lifestyle, rapid development of technology, faster flow of information and communication, emergence of new knowledge domains and their instant global pervasion, the working environment of contemporary designers is constantly changing. These circumstances generate completely new characteristics and diversification of design as a phenomenon. Society needs a new kind of design professionals who play an important role as mediators and interpreters of change in a social, technological and cultural context. They should be able not only to assimilate various and complex knowledge but also to formulate adequate concepts and create products reflecting the spirit of modern times. Under these conditions, new challenges emerge for design educators. It is necessary to update and modernize the outdated educational process, including design education. [1] [2] [3]

When interactive educational methods are considered, most often introduction of intelligent technologies is meant. Teaching processes are provided with digital appliances like personal computer for each student, visualisers, interactive whiteboards, interactive projectors, learning response systems, digital signage systems, interactive touch screen monitors, etc. However, application of this promising type of interactive methods requires considerable financial investment in education which is unthinkable for the time being because of the economic situation in our country. To compensate for the shortcomings and the substantial discrepancy of the teaching process, we have created a new programme introducing interactive education through other non-conventional means. We aim to involve students and stimulate their active participation in the educational activities. Our objective is to provoke students to gain their own knowledge through researching and revealing certain

information and personal experience, to expand their horizons and help them realize the relevance of the obtained knowledge to their future profession.
In this paper we consider the broad meaning of the term interactivity which is understood as every form of interaction and communication taking place between learners and lecturers, between learners, and between learners and training resources, including information and communication technologies.
Traditionally it is accepted that knowledge can be directly transferred from the teacher to the learner. Contrary to this, in interactive education students become constructors of their own knowledge while learning is transformed from passive consumption into active quest for meanings and values – a co-participation in the educational process. Dialogue is established as the most common and underlying form of knowledge, ideas and opinions interchange where all participants in the educational process are equal or put figuratively, "everybody teaches everybody".
Other characteristics of our programme are: focusing on the most topical, problematic and conflicting issues which become subject for discussion and debate in search of heuristic solutions based on interdisciplinarity and creativity of the individual and the group as a whole.
Examples of the implementation of interactive methods in the training of students in Engineering Design (Interior and Furniture Design) in two fundamental disciplines – Form-formation and Theory of Composition will be presented in the paper.

2 INTERACTIVE METHODS IN FORM-FORMATION TEACHING COURSE

The theory of form-formation studies forms and spaces as objective physical phenomena and in its essence it belongs to the family of natural sciences. This science seeks to ascertain the logic of the form in the objective world, taking into account the forces and conditions of the material physical environment. It is an interdisciplinary science and throws bridges to other sciences such as mathematics, chaos theory, fractal geometry, physics, synergetic, theory of modelling, bionics, robotics, etc. [4] The interdisciplinary positioning of the theory of form-formation in education is favourable for the formation of interdisciplinary thinking of the up-and-coming designers. In this way they can develop professional skills to solve complex problems and create innovative products through integral thinking and combination of the novel acquisitions of various fields of the scientific knowledge. Another advantage of this approach is that students master a language that will help them to integrate and work on common projects in collaboration with specialists from other fields.
We also adopt a series of systematically connected activities attacking the discipline from different points of view – both on the theoretical level and the level of practical and experimental tasks. One of the objectives is to encourage students to approach assignments creatively, to develop further the theoretical knowledge and interpret it in their own way. We position them in various situations in order to stimulate their artistic reasoning, and to teach them how to derive benefits and adapt obtained knowledge in future work. We endeavour to invite and motivate interest towards the discipline and broaden students' knowledge through introduction of new forms of dialogue in the educational process. Focusing on the advantages of the proactive level of interactivity our aim is to achieve better educational results. [5]

2.1 Case Study: Symmetry

Symmetry has an important place in the training course. It is considered from multiple aspects both in lectures and seminars in search of achieving profound knowledge of symmetry's fundamental role in the world. Students are introduced to the arduous research undertaken for example in crystallography before the magical 17 symmetry groups of finite figures and 230 symmetry groups of infinite crystal systems were discovered. These symmetries have existed in a 'hidden form' since the art of ancient Egypt. [6] The art of covering the plane with repetitive patterns is observed in all cultural traditions. In connection with this theme, students are assigned an essay "Analyze the symmetry of a tessellation at your choice from the palace complex Alhambra in Andalusia, Spain".
We generally assume that essays are indispensable in design education. The essay is a form of individual reasoning, decoding and approbation of an idea – the rules of building the chosen tessellation in the respective case. This is a specific research project but at the same time it is training for verbal description, expression and well-grounded argumentation of the attained knowledge. In parallel, students work on thematic assignments during seminars – "Wallpaper groups" and "Analysis

of plane tessellation patterns". They learn how to recognize and categorize tessellations on the base of the applied symmetry operations and afterwards they generate their own concepts.
Following the logic of Curie's universal principle of applying symmetry of space on solids own symmetry, a conclusion is reached that all terrestrial forms are determined in a struggle with **gravity**. [7] During the seminars students become acquainted with regular Platonic and semi-regular Archimedean polyhedrons, and learn how to describe them through the three elements of symmetry – vertices, edges and faces. A creative task comes next: to interpret the specific shape with application of various deformations of these elements using different materials. Then we go on to analyze more complex natural forms and classify them in two main categories depending on the symmetry they are subjected to – radial or bilateral. Objective causes for acquiring the respective form are identified and parallels with design or architectural objects are made. Students are also asked to write an essay about the phases of symmetry of a falling drop.
Special attention is paid to **symmetry of similarity** because it is this type of symmetry that links and 'harnesses' symmetry and rhythm, space with time, and characterizes motion. [8] Students observe the symmetrical arrangement of leaves in plants (phyllotaxis) and through its mathematical description construct logarithmic spirals and study the connection with the golden mean.
Provoked by the rapid advance of computer technology in the design profession and the possibilities for generation of novel shapes based on simple algorithms, we incorporate **fractal geometry** in the discipline. To learn the specific terminology and develop analytical skills we challenge the students to find the generation scheme of a given fractal on their own. After that, working in teams they design three dimensional fractal structures after preliminary created generative system. We recommended them to use the web pages of the lecturers, read the published materials and study the given examples in their self preparation. We also encourage the use of online trainings, video tutorials, animations, etc.

2.2 Case Study: Form Description and Modelling

Students are introduced to the types of description and modelling of forms, the elements characterizing modelling and the process of modelling itself based on symmetry and rhythm. Starting from the postulate that the object we are going to model is the original, and the model is its image, materialized with any tools, students make verbal, geometrical and structural models of objects such as leaf or tulip (depending on the season) in three consecutive essays and class assignments. Then they interpret the obtained models in design objects. We aim to develop heuristic thinking through analyzing a natural object, generalizing fundamental structures, constructions and models. On this basis arguments and designs of specific products are proposed.
Going through every single stage of model construction is an important process in design education. Through systematic learning of the structure of the natural object students' power of observation is increased, skills for differentiation of the essential from the ephemeral are developed and techniques for design experimentation based on interpretation of drawn abstractions of forms found in nature are trained. Relevant to this case study is the stress put on **bionics** both in the lectures (the theme of the lecture is "Bionics and its relation to form-formation") and seminars where students study in depth the problem of modelling with the bionics mini-project they work on. This very topical science, linking biology and design, combines living systems developed in a long evolutionary process with technological achievements to offer design solutions of various problems.

2.3 Case Study: Extracurricular Activities

Students are able to participate in a variety of extracurricular educational activities. Such is the work on research papers with themes relevant to the discipline – for example synergy, bionics, robotics, etc. These papers proved to be very useful not only for the students who prepared them but also for the rest who did not listen passively but participated actively in the discussions that followed. In this way we stimulate students to learn the latest novelties of such modern sciences by reading specialized literature and we develop their presentation skills, the ability to defend their opinion and debate on various themes. The two organized competitions which challenged students to apply knowledge learned in form-formation classes in the design of real products turned out to be exceptionally interesting. The themes were respectively New Year's and Easter decoration (including interior decoration, Christmas tree decoration, greeting cards, egg decoration, gifts and gifts packaging). Figure 1. We observed that the introduction of a competitive aspect influences students' motivation, while the prizes awarded to the winners additionally stimulated students to participate in the initiative.

The results of the competitions were published in the web pages of the lecturers, which is a form of popularization of the honoured students among their colleagues who have followed these pages since they were created. This raises students' self-confidence and fills them with ambitions to take part in other design contests, which we are happy to observe is already happening.

Figure 1. Examples of competition entries

3 INTERACTIVE METHODS IN THEORY OF COMPOSITION TEACHING COURSE

The aim of composition in design is the achievement of artistic vision of the object and the effect of form and space on human perception. In its essence the theory of composition integrates and belongs to the family of humanities. Like form-formation, it is an interdisciplinary science and throws bridges to other sciences such as psychology, ergonomics, semiotics, semantics, pragmatics, art criticism, aesthetics, sociology, stylistics, etc. [4] Teaching of this discipline puts the stress on the notion of design like art, meaning that interrelationships between the design object and emotional perception of the viewer are at the focus of attention. Introduction of sciences directly linked to composition and their presentation through different approaches based on educational games and competitiveness contribute to the development of a sense of composition in students and accustom them to the proper application of compositional laws, principles and means in search of a specific emotional effect.

3.1 Case Study: Semiotics

The inclusion of semiotics in the curriculum introduces students to the main categories sign and sign system, the concept of denotation and connotation, the mechanisms of information coding and decoding. Semiotics terminology assists the study of the complex interrelations in the system 'human-product', the relation between form and essence and the important role that designers play for transformation of semantic information in design objects. Assignments given to students again aim at the formation of broader knowledge through essay writing and working on individual creative projects. The theme of the essay is: "Describe the semantics of the throne". This is meant to teach students to decode the denotative and connotative meanings put into the given examples – a furniture item with specific visual characteristics. Hence they learn how to read coded semantic information but also to do the opposite – to code information into their designs. Once they have mastered this visual language, the process of coding of specific meaning in the product will be easily done.

The aim of the class assignments is to teach students how to code meaning by showing them how to use semiotics as a means of multilayered meaning integration in design objects. Such is the assignment to design a sun symbol – one of the most worshipped and interpreted objects since the dawn of human civilization. After a verbal description of the characteristics, personal meanings of the sun and associated emotions with it, students are expected to find the appropriate graphic elements in order to visualize the chosen definitions. An essay assigned as a kind of ongoing control on the theme is: "What meanings should be coded in a baby cradle or child crib designs?"

3.2 Case Study: Psychology of Perception

It is the designer's responsibility to create the artificial material environment and ensure that it conforms to human behaviour and emotions. The designer should be able to recognize the characteristics of human perception and the factors influencing it, to direct and manipulate them in harmony with designated utilitarian and aesthetic aims. In the seminar classes we acquaint students

with the basic laws and mechanisms of perception, the methods of manipulation of forms and spaces synchronous to the desired psychological and emotional effects. The stress is put on the very popular concept of user experience and emotional impact of products and environments on humans. In this relation students are given an essay on "The interior that impressed me". In seminars students design graphic assignments where they are asked to express different emotions using specific graphic elements (e.g. lines).

Since the origin of **gestalt psychology**, in the centre of its research field being visual perception and visual models, it has drawn the attention of artists and designers. Gestalt psychologists' writings turn into heuristic base for creative thinking in general. A number of principle positions like the relationship between figure and ground, priority of the whole to its parts, proximity and similarity, etc. are directly transferred from Gestalt psychology research into composition teaching course. The difference of the approach we adopt is that we explain the most popular principles of composition by applying the aspect of gestalt psychology to composition. In this way information is presented persuasively, students rationalize the tools for harmonization and learn how to apply them in their designs. In addition to seminar classes where students illustrate some of the most popular gestalt principles or explore the possible interrelations between figure and ground, we encourage them to search for real examples in the field of interior and furniture design. This enhances their observation skills and directs their attention towards the reasons causing the relevant impact of the analyzed object.

3.3 Case Study: Extracurricular Activities

The student educational-scientific conference on the theme "Application of Gestalt Principles in Design" we organized was an absolute novelty for our university. This is an exceptionally appropriate form of self-training. By taking part in the preparation of the conference students learn how to construct their own knowledge of composition and share it with their fellow students and lecturers. We were very pleased to see that almost half of the students participated. Figure 2. The conference gave an opportunity for more detailed discussion of gestalt principles, which cannot take place within the limited time of the lecture classes. It proved to be an excellent platform for manifestation of the striving and ambitious students. The creation of a competitive environment which is an engine of creativity in the arts and design circles was also an important issue. In the beginning a poster design competition was announced and the best entries were spread in the university and published in the web pages of the lecturers giving wide publicity of the conference. Thus considerable interest towards the theme was aroused among students and lecturers from other university departments.

The conference speakers gained experience in presentation techniques, ideas and thesis argumentation and improved their public speaking behaviour. Learning the art of rhetoric and performance is important for professional design training because designers should be able to persuade investors, clients and colleagues in the adequacy of their ideas and the quality of their products. All participants were given certificates and conference materials will be published in a digital edition.

Figure 2. Examples of conference posters; student conference

4 ANALYSIS OF THE RESULTS OF AN ANONYMOUS SURVEY

To assess the outcomes of the implemented interactive educational methods a survey was carried out where 58 out of 60 third year students who studied Form-Formation (in 2011) and Theory of Composition (in 2012) participated. The survey comprised 15 questions concerning teachings in Theory of Composition. The main objectives of the survey were to verify the effectiveness of

interactive methods, to evaluate students' attitude towards the discipline – whether and how it has changed and to gain valuable recommendations and critical notes which can benefit our future work.
The results of the survey unambiguously showed that the students studied the subject with interest: 92% of the respondents gave a positive answer to the question "Do you find Theory of Composition classes to be interesting," 25% answered they were 'exceptionally interesting'. 93 % responded they attended classes willingly, 14 % – very willingly. Gestalt principles (95%) and semiotics (43%) were specified as the most liked themes. This shows that the themes we have selected for class assignments and the conference have provoked students' interest and also that our aim to broaden their range of knowledge and introduce interdisciplinarity in education has been successfully achieved. Special attention should be paid to the fact that 88% of the participants in the survey gave positive answers to the question "Were there enough possibilities for creative participation". This fulfils another goal we had set in the beginning – to provide various opportunities for student creative expression depending on their personal preferences. Participation in the conference with posters and papers was approved by 91% of the respondents. In general most of the students are satisfied with their work and find that they have coped successfully with the assignments (91%). Especially important for us is the finding that students gain useful knowledge for their future work and develop professional skills and competences during this educational course.

5 CONCLUSION

Analysis of the results of the anonymous survey of students' opinion on the quality of education in the specified courses shows that our efforts to motivate and involve them to participate actively in the educational process have been successful. Providing a platform for debate, heuristic thinking and collaboration has been a key component of our education paradigm. We have tried to create a positive learning environment by rejecting the top-down fashion in education where information is passively memorized and by encouraging students to collaborate, ask questions, express opinions, join group discussions and develop ideas. The activities we have included in the programme have been systematically selected in order to cover more broadly the constantly evolving themes of the disciplines we teach. We have been supportive and allowed students to develop intrinsic motivation and find their personal approach to explore and expand their knowledge in the field of design. It is our conviction that when knowledge is gained because of students' curiosity and personal will to improve contributes not only to satisfaction of learning itself but also to the future interpretation of this knowledge in their professional career. Though we lack the technological base we tried to present information persuasively, stimulated creative approach and created communicative and collaborative environment.
We can generalize that the conclusions regarding the implementation of these interactive methods of education are very encouraging. We noted that the students not only show more respect towards our work but also contributed actively to the learning process and express desire to participate and organize more conferences and competitions even outside the university. Fostering a passion for design profession is observed in many of the students, which according to us is our most significant achievement.

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